

Steps Toward Regulatory Realization of Digital Twins

Closing Panel Session – September 16, 2021

Moderator: Eric Benner, NRC

Jeremy Bowen, NRC

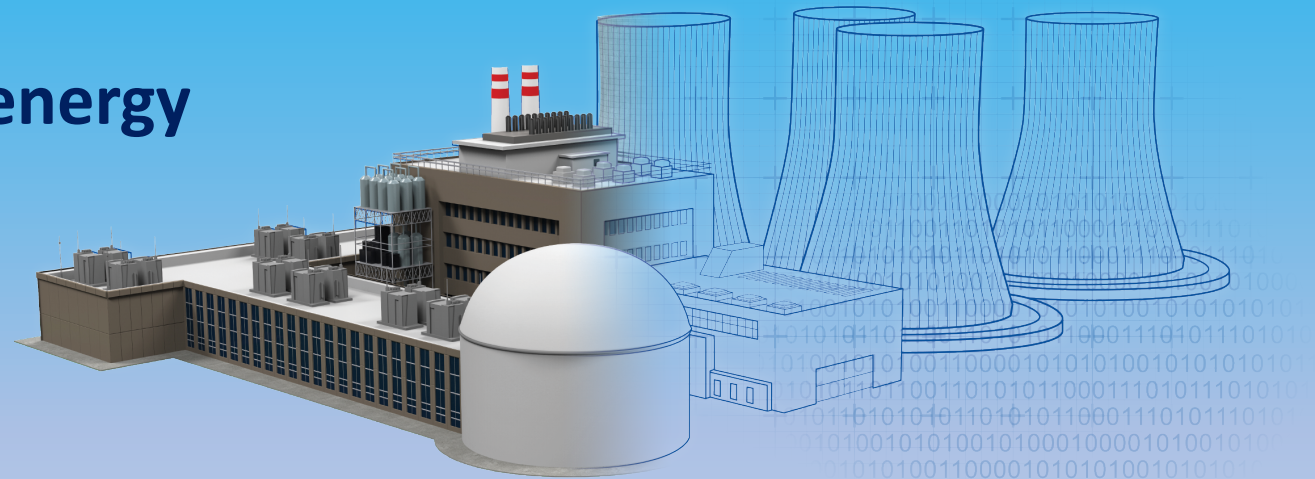
Tom Braudt & Steve Vaughn, X-energy

Paul Keutelian, Radiant

James Slider, NEI

Anthonie Cilliers, Kairos Power

Brian Golchert, Westinghouse

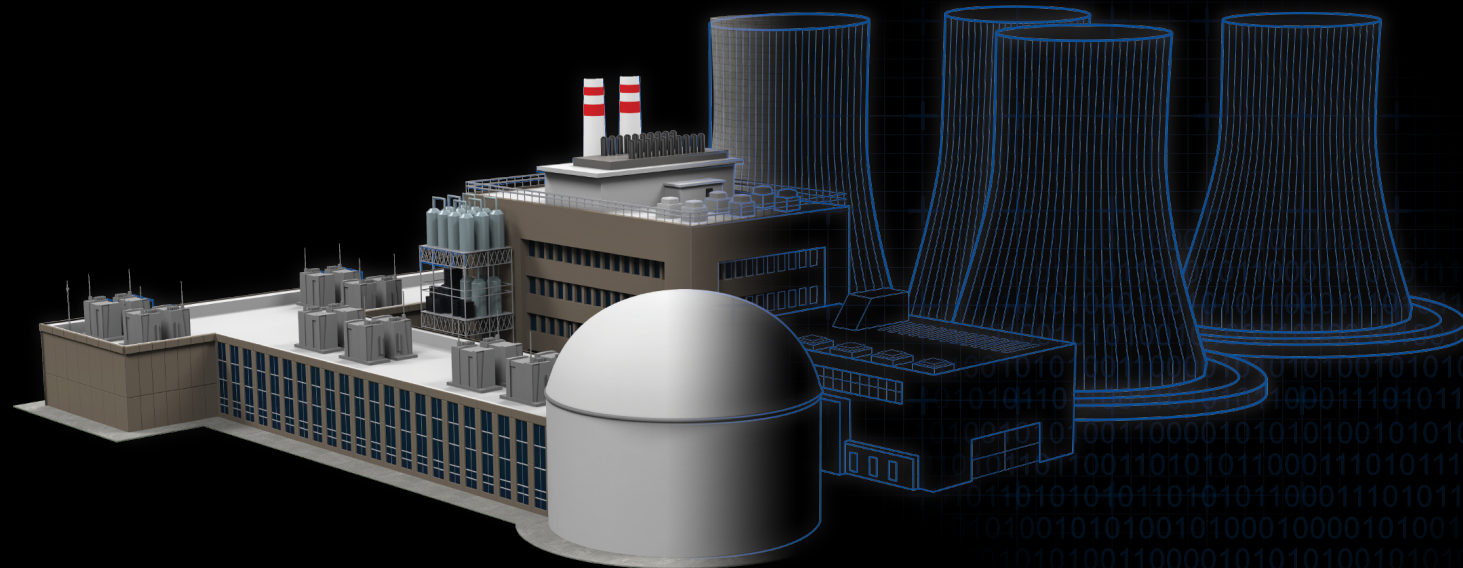


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Digital Twins - Regulatory Viability

Jeremy Bowen



Digital Twins Project Plan



**TECHNICAL
PREPAREDNESS**



**REGULATORY
READINESS**



**ASSESSMENT OF
STANDARDS**



**COMMUNICATION
& KNOWLEDGE
MANAGEMENT**

PREPAREDNESS



**FFR
PROJECT**

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Takeaways Thus Far



The State of Technology
of Application of Digital
Twins



Public Workshop #1



Assessment of the state of DT
technology in nuclear reactor
applications



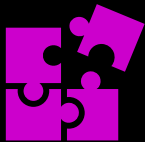
Widespread interest with
>400 participants across
the globe



Proven benefits



Technique is increasing
and developing rapidly



Development of a common
understanding

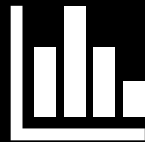


Need for community of
practice to collaborate

Access Link: [ML21160A074](https://www.mlr.gov/record/ML21160A074)

Access Link: [ML21083A132](https://www.mlr.gov/record/ML21083A132)

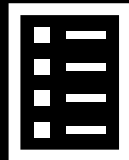
Active & Future Tasks



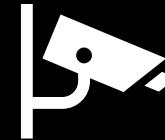
Technical Challenges and Gaps for Digital Twins in Using Data Analytics, ML/AI and Multi-Physics Models



Technical Preparedness – Safeguards and Security in Digital Twins



Regulatory Readiness Levels and Gaps Pertaining to Digital Twin Technologies for Nuclear Reactor Applications



Online Monitoring for Enhanced Diagnostics and Prognostics



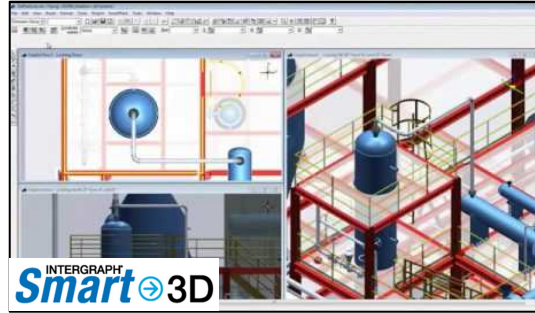
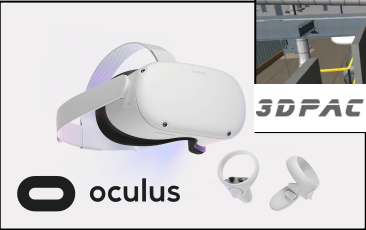
Steps Toward Regulatory Realization of Digital Twins Xe-100 Licensing Perspectives

Tom Braudt and Steve Vaughn, X-energy Licensing

September 16, 2021



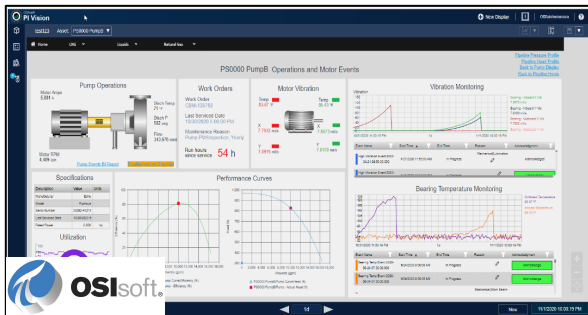
Xe-100 Digital Twin Tools



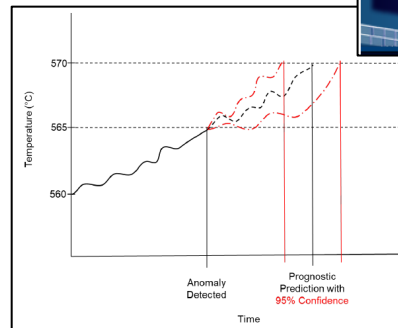
3D Models with AR / VR



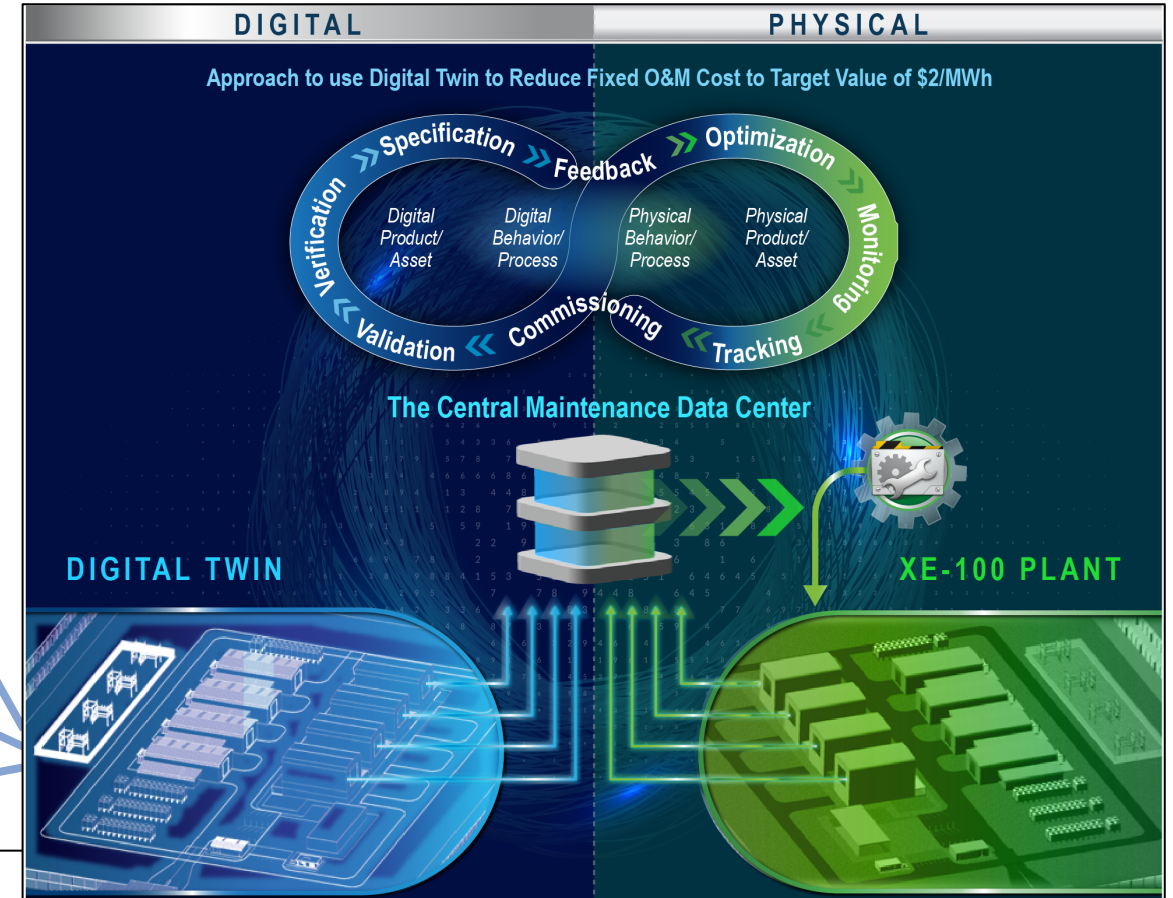
Operator Training Simulator



Plant Historian



AI / ML Models

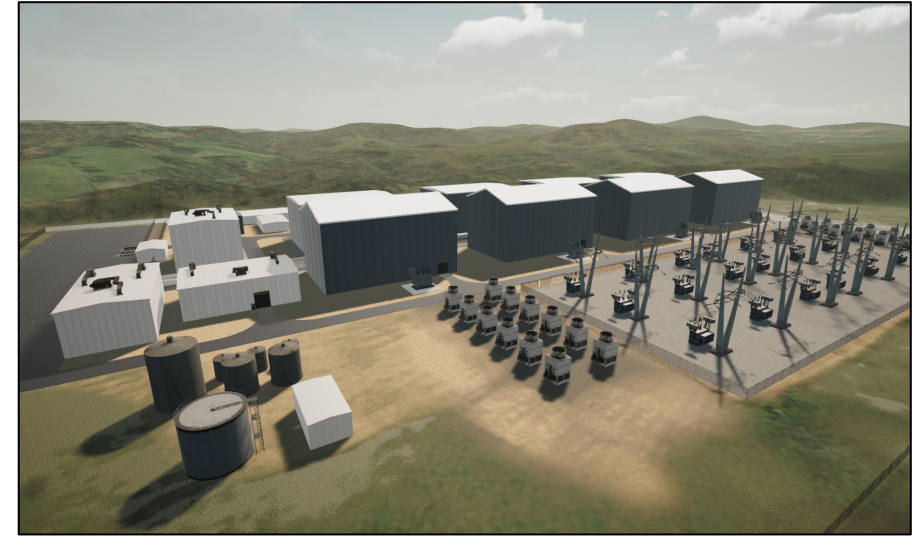




Hi-Fidelity Simulator and 3D Models



Simulator Certification
Simulator HFE Validation





Regulatory Intersections with the Xe-100 Digital Twin

Digital Twin Primary Purpose is Plant Economics – Not Regulated

Some Intersectionality with:

- Xe-100: extensive use of digital control and monitoring systems
- Maintenance Rule – predictive maintenance
- Simulator fidelity and configuration management
- Human Factors Engineering – predictive trending and intelligent alarms reduce operator workload
- NLO/Maintenance/I&C/RP Training – multi-role approach
- ALARA dose reduction
- Security analytics and what-if scenarios
- Fire Detection – intelligent dispatch and response
- Support load-follow, industrial heat, hydrogen production

Strong NRC Staff Interest in Understanding Xe-100 Digital Twin Capabilities and Usage

- Control Room - staffing methodology
- Operator Training - methodology and workload



Digital Twin Regulator Pathway – Future Considerations

Use of AI / ML for Control Functions

- Ensuring regulatory framework positioned to support
- Leverage lessons-learned from safety-related digital retrofits (cyber)
- NUREG/CR-7273 starting point

Dynamic PRA Usage - initiating event prediction via AI

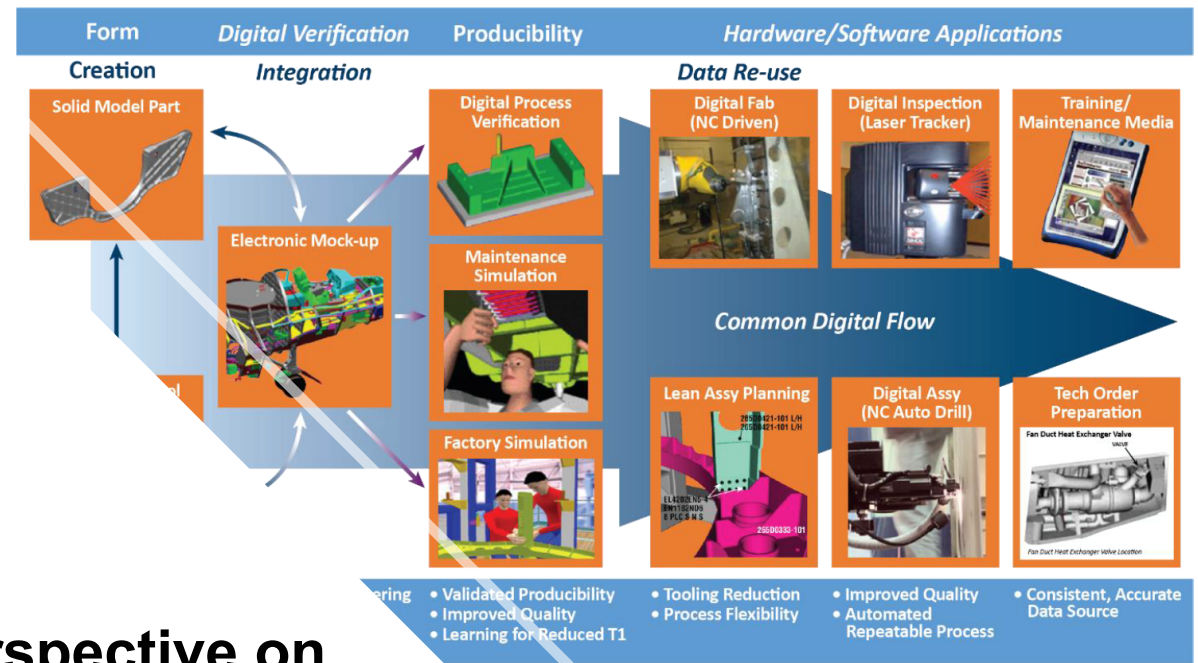
Pre-emptive utilization of “Remaining Useful Life” (RUL) for equipment

Sensor Drift Detection

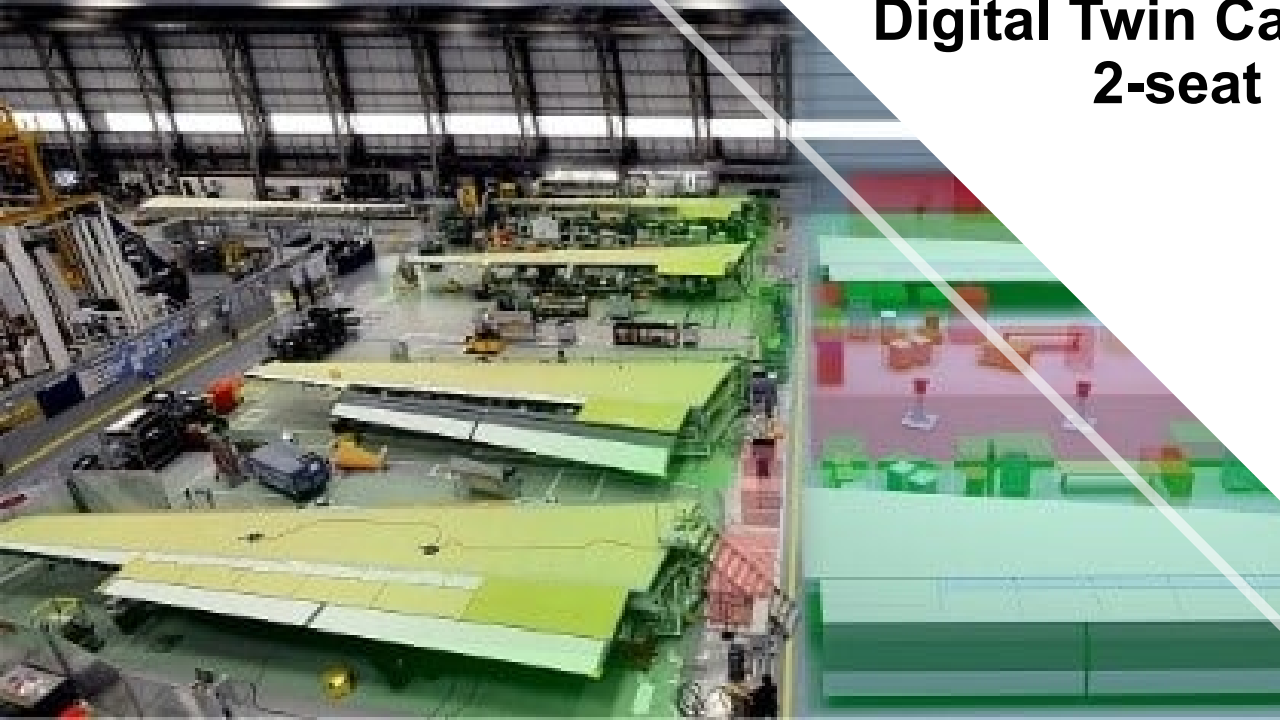
Cyber Security Requirements for Control Functions – DoD Lessons Learned

Encourage Research at NR/ INL/ORNL to Support Control Functions

Making ‘digital twins’ to monitor and control tomorrow’s reactor designs - INL



A Personal Perspective on Digital Twin Capabilities: no 2-seat F-35s



Using Digital Twins to Support Regulations

Paul Keutelian

September 16, 2021



Vision | Radiant

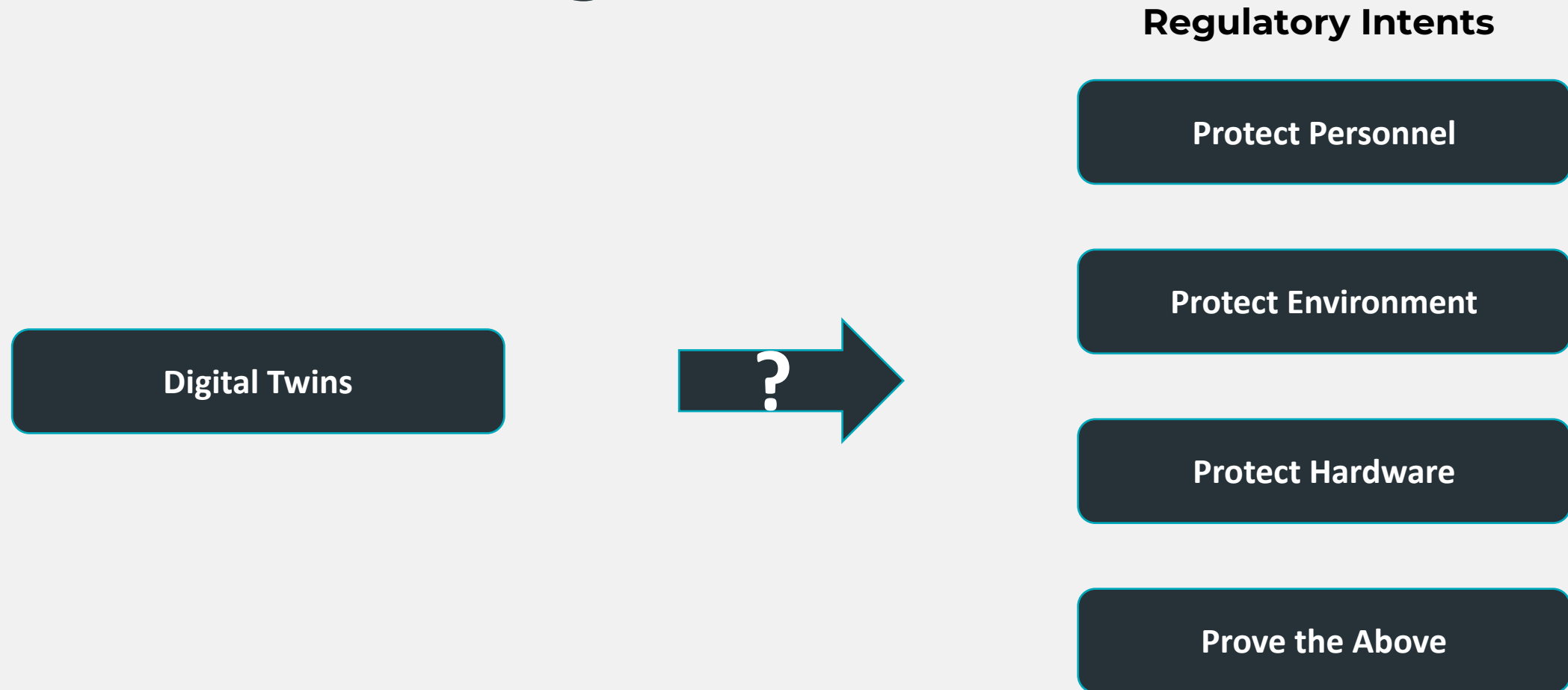


Make Nuclear Portable

Maximize speed of iteration to get to a buildable product

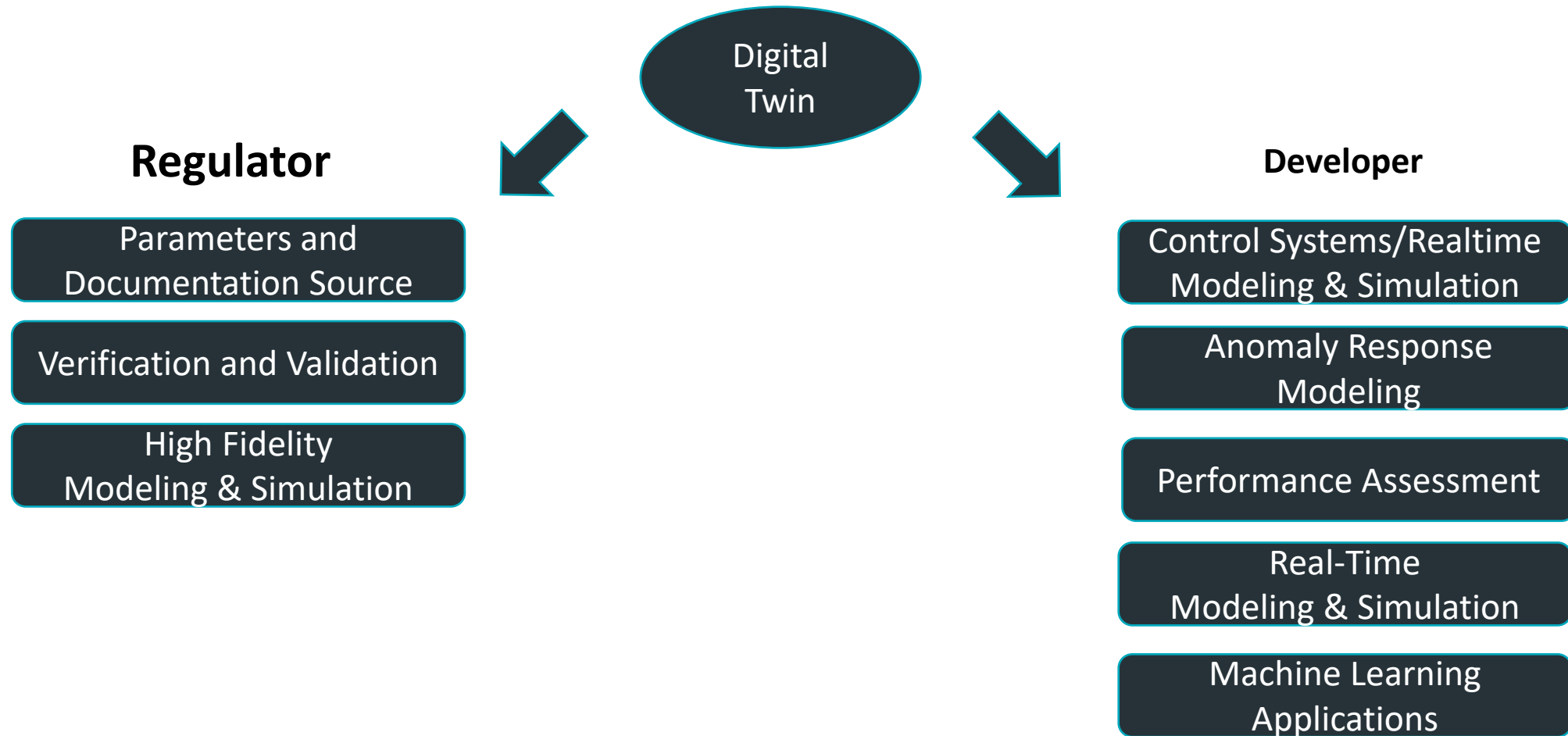
Provide streamlined regulatory analysis

Novel Challenges



Digital Twins are a powerful potential to answer these core questions, the challenge comes from understanding where is it appropriate to use this tool, and how do we work with regulators to build confidence?

Digital Twins as a Tool



Digital Twins are a common tool between regulators and developers to ensure common sources of information for aspects relevant to them.

Contributions

- Internal analysis documentation standardization
- Visualizations for eased introduction to analysis
- Automation of explicit analysis flows
- Common interface with Regulators



JAMES SLIDER
TECHNICAL ADVISOR



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SENIOR MANAGER

INSTRUMENTATION, CONTROLS AND ELECTRICAL

BRIAN GOLCHERT

PRINCIPAL ENGINEER



Enabling Technologies for Digital Twin Applications for Advanced Reactors and Plant Modernization

September 14-16, 2021

Thank you for your participation in this workshop. The proceedings for the workshop will be publicly available in the next few months. Please provide any comments or feedback to one of these workshop sponsors.

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